What is claimed is:

1. An excavator, comprising:

a boom;

a cutter head, mounted on the boom, for excavating *in situ* material;

a body, wherein the boom is rotatably mounted on the body;

a plurality of grippers operable to apply pressure against opposing surfaces of an excavation to hold the body in a selected position and orientation, wherein the boom axis of rotation is at least substantially parallel to a direction of movement of at least one of the grippers; and

a control system operable to effect operation of the excavator in a manual mode in which an operator controls operation of the boom and cutter head and the plurality of grippers and an automatic mode in which the control system controls operation of the boom and cutter head and the plurality of grippers.

2. The excavator of Claim 1, further comprising:

a first operator interface located on or near the excavator;

3. The excavator of Claim 2, further comprising:

a second operator interface located remotely from the excavator and in communication with the first operator interface; and wherein the task supervisor is configured as an engine that invokes independent state machines, at least a first state machine performing excavation and at least a second state machine performing at least one of (a) translation of the machine in a first plane from a first to a second location and (b) steering of the excavator to realize a desired excavator orientation in a second plane orthogonal to the first plane.

4. The excavator of Claim 1, wherein the control system comprises a task supervisor and the excavator includes at least one thrust actuator operable to extend and retract the cutter head and wherein the task supervisor is operable to set the excavator to a continuous boom sweep state and a single boom sweep state and wherein the configurable

variables in the continuous and single boom sweep states comprise a plurality of boom swing rate, boom swing limits, thrust actuator position, thrust extension between boom rotations, and thrust actuator force limit.

5. The excavator of Claim 1, wherein the boom comprises at least one swing actuator to rotate the boom and wherein user functions available in the manual mode include cutter head gripper retract, cutter head gripper extend, thrust actuator retract, thrust actuator extend, swing actuator enable, swing actuator disable, and extension and retraction of each of the main and rear grippers.

6. The excavator of Claim 5, wherein each of the plurality of grippers, the at least one thrust actuator, and the at least one swing actuator are each settable to a pressure control function and a position control function.

7. A excavator of Claim 6, wherein a first chamber of one of the plurality of grippers is set to the pressure control function and a second chamber of the one of the plurality of grippers is set to the position control function.

8. The excavator of Claim 1, wherein the boom is actuated by at least two swing actuators and further comprising a swing angle controller operable to (a) convert the swing actuator positions, at a selected point of time, into a swing angle measurement; (b) convert a swing angle measurement into swing actuator positions at the selected point of time; and/or convert a commanded swing torque into corresponding swing actuator pressures for the at least two swing actuators.

9. The excavator of Claim 8, wherein, when one of the swing actuators is at or near a minimum extension, the position of the other cylinder alone is used to determine at least one of the swing angle and the swing torque.

10. The excavator of Claim 1, wherein the boom comprises at least two swing actuators and further comprising a swing angle controller operable to convert a measured hydraulic pressure in and a cylinder position of at least one of the swing actuators into the swing torque.

11. The excavator of Claim 1, wherein the boom comprises at least two swing actuators and, when a first swing actuator is in a singular region, the second swing actuator alone controls the boom torque and position.

12. The excavator of Claim 1, wherein the plurality of grippers and the at least one thrust actuator are lockable via operator controlled check valves and the control system.

13. The excavator of Claim 1 wherein the control system comprises a task supervisor and the task supervisor is operable to set the excavator to a continuous boom sweep state, wherein, in the continuous boom sweep state, the following steps are automatically performed:

first extending the at least one thrust actuator to contact the cutter head with an excavation face;

second rotating the boom and cutter head in a first direction to excavate material from the excavation face;

third extending the at least one thrust actuator a selected distance; and

fourth rotating the boom and cutter head in a second direction, opposite to the first direction, to excavate additional material from the excavation face.

14. The excavator of Claim 13, wherein the first extending, second rotating, third extending, and fourth rotating steps are repeated until one of the at least one thrust actuator is extended a predetermined distance, a failure occurs, or the boom stalls.

15. The excavator of Claim 1 wherein the control system comprises a task supervisor and the task supervisor comprises a mining mode sequencer that is operable to

sequence invocation of a continuous sweep cycle generator module and a walk sequencer module.

16. The excavator of Claim 1, wherein the control system comprises a cutting face profile generator operable to determine a real-time or near real-time profile of the excavation face after each boom rotation and, based on the excavation face profile, determine at least one of a sweep angle and radius of curvature of a next boom rotation.

17. The excavator of Claim 1, further comprising an optimization module operable to monitor one or more selected parameters during excavator operation and, based on the monitored one or more selected parameters, provide recommended parameter changes.

18. The excavator of Claim 17, wherein the one or more selected parameters include at least one of amount of material excavated and grade of the excavated material.

19. The excavator of Claim 1 wherein the control system comprises a task supervisor and the task supervisor comprises a swing cycle optimization module operable to automatically reverse direction when at least one of a thrust force measured in the at least one thrust actuator and the swing torque drops below a predetermined threshold.

20. The excavator of Claim 1, wherein the at least one thrust actuator and plurality of grippers include an end of stroke sensor and wherein the corresponding at least one thrust actuator and gripper is assumed to be retracted when a respective retract end of stroke sensor is activated, extended and in contact with at least one of the excavation surfaces when a pressure and/or force sensor for the corresponding at least one thrust actuator and gripper indicates a hydraulic pressure and/or force above a predetermined amount and the respective end of stroke sensors are not activated, and extended and not in contact with at least one of the excavation surfaces when only one of the end of stroke sensors is activated.

21. The excavator of Claim 1, further comprising at least one control loop operable to receive a command controlling operation of the at least one thrust actuator and plurality of grippers, convert at least one of position setpoint and a pressure setpoint to a corresponding actuator control command to a controller corresponding to the at least one thrust actuator and plurality of grippers, receive a feedback signal from at least one of a pressure and position sensor associated with the at least one thrust actuator and plurality of grippers, compare the feedback signal with the actuator control command, and adjust the actuator control command based on the comparison.

22. The excavator of Claim 1, wherein the control system comprises a kinematic module operable to convert actuator feedback signals into attitude information and attitude commands into actuator control signals and compare the attitude commands with the actuator feedback signals to output an error vector, wherein the error vector comprises an adjustment for roll and an adjustment for pitch.

23. The excavator of Claim 22, wherein the kinematic module is further operable to convert the pitch and roll adjustments into equivalent actuator control signals.

24. The excavator of Claim 1, wherein the boom has an angle of rotation and comprises a first and second swing actuator and wherein, at a first boom position, a first longitudinal axis of the first swing actuator intersects a second longitudinal axis of the second swing actuator within an angle of rotation of the boom and, at a second boom position, the first longitudinal axis of the first swing actuator intersects the second longitudinal axis of the second swing actuator outside of the angle of rotation of the boom.

25. The excavator of Claim 11, wherein, when a first swing actuator is at the singular region, a second swing actuator is extending or retracting.

26. The excavator of Claim 25, wherein, when the second swing actuator is at the singular region, the first swing actuator is the other of extending or retracting.

27. The excavator of Claim 1, further comprising a position sensor in contact with at least one of the at least one thrust actuator and the plurality of grippers, the position sensor comprising a rotational arm, a roller on a distal end of the rotational arm, a sensing unit engaging a proximal end of the rotational arm, and a spring engaging a the rotational arm and resisting rotation of the rotational arm.

28. The excavator of Claim 1, further comprising:

a plurality of check valves in fluid communication with the at least one thrust actuator and plurality of grippers and a hydraulic fluid line, the check valves being configured to close when a hydraulic pressure in the hydraulic fluid line falls below a selected threshold, whereby hydraulic pressure is at least substantially maintained in the at least one thrust actuator and plurality of grippers.

29. The excavator of Claim 28, further comprising:

a hydraulic return line in fluid communication with the plurality of check valves, the hydraulic return line being operable to permit the at least one thrust actuator and plurality of grippers to be drained of hydraulic fluid when the plurality of check valves are closed.

30. The excavator of Claim 29, further comprising:

An emergency retract line in fluid communication with the plurality of check valves and configured to exert a sufficient hydraulic pressure against each of the closed plurality of check valves to overcome the reverse pressure applied against each check valve by a corresponding one of the at least one thrust actuator and plurality of grippers, whereby the valve is opened and hydraulic fluid drained via the return line.

31. The excavator of Claim 1, wherein the boom comprises one or more swing actuators in fluid communication with at least one corresponding variable orifice valve and a variable output hydraulic fluid pump in fluid communication with the at least one variable orifice valve, wherein the at least one variable orifice valve varies a rate of hydraulic fluid

flow into the one or more swing actuators and a differential pressure across the one or more swing actuators, and wherein the pump varies a hydraulic fluid flow and pressure provided to the at least one variable orifice valve, whereby both a swing velocity and a swing torque of the boom are controlled.

32 The excavator of Claim 1, further comprising a vacuum mucking system in communication with the cutter head.

33. The excavator of Claim 1, further comprising a plurality of water jets positioned on the cutter head to assist in removal of the excavated material.

34. The excavator of Claim 1, wherein the control system is operable to place the excavator in a predefined fault response state when a fault is detected and wherein the predefined fault response state synchronizes a transfer of excavator control from a first computational component to a second different computational component and causes pending control commands to be disabled.

35. The excavator of Claim 34, wherein the fault includes loss of hydraulic pressure, excessive levels of vibration, software conflicts, configurable parameter conflicts, and configurable parameters falling outside of predetermined thresholds.

36. The excavator of Claim 1, wherein each gripper and the at least one thrust actuator each comprise at least one of (a) one or more end of stroke sensors and (b) one or more position sensors and one or more pressure and/or force sensors.

37. The excavator of Claim 1, wherein the control system comprises a task supervisor.

38. The excavator of Claim 1, wherein the operator can select between the manual and automatic modes.

39. An excavation method, comprising:

providing an excavator, the excavator comprising a boom; a cutter head, mounted on the boom, for excavating *in situ* material; and a body, wherein the boom is rotatably mounted on the body and includes first and second swing actuators to effect rotation of the boom;

rotating the boom in a first direction through a first angle of rotation, wherein, when the boom is at a first angle of rotation, the first swing actuator is at the first swing actuator's minimum stroke and the second swing actuator is not at the second swing actuator's minimum or maximum stroke and, when the boom is at a second angle of rotation different from the first angle, the second swing actuator is at the second swing actuator's minimum stroke and the first swing actuator is not at the first swing actuator's maximum or minimum stroke.

40. The method of Claim 39, wherein the excavator comprises a plurality of grippers for exerting pressure against opposing surfaces of an excavation and the boom axis of rotation is at least substantially parallel to a direction of movement of at least one of the grippers.

41. The method of Claim 39, wherein the boom has an angle of rotation and wherein, at a third angle of rotation, a first longitudinal axis of the first swing actuator intersects a second longitudinal axis of the second swing actuator within an angle of rotation of the boom and, at a fourth angle of rotation, the first longitudinal axis of the first swing actuator intersects the second longitudinal axis of the second swing actuator outside of the angle of rotation of the boom.

42. The method of Claim 39, wherein, when the first swing actuator is at the first angle of rotation, the second swing actuator is extending or retracting.

43. The method of Claim 42,wherein, when the second swing actuator is at the second angle of rotation, the first swing actuator is the other of extending or retracting.

44. A method for operating an excavator, comprising:

providing an excavator, the excavator including a plurality of hydraulic actuators, a plurality of check valves, a hydraulic fluid supply line in fluid communication with the check valves and the hydraulic actuators, a hydraulic fluid return line in fluid communication with the check valves and the hydraulic actuators, and an emergency retract line in fluid communication with the check valves;

detecting a fault in the hydraulic system;

closing the check valves in response to the detecting step to maintain at least substantially hydraulic pressure in the hydraulic actuators;

pressurizing the check valves with the emergency retract line to open the check valves and effect drainage of the hydraulic fluid from the hydraulic actuators.

45. The method of Claim 44, wherein, in the pressurizing step, a corresponding pressure applied to each check valve is sufficient to overcome a respective hydraulic pressure exerted against the check valve by the corresponding hydraulic actuator.

46. The method of Claim 44, wherein the fault is a hydraulic fluid pressure in the hydraulic fluid supply line falling below a predetermined threshold.

47. A method for operating an excavator, comprising:

providing an excavator, the excavator comprising a body, a cutter head, and a plurality of hydraulic actuators;

setting at least one hydraulic fluid-containing cavity in each of a first set of the hydraulic actuators to a pressure control function; and

setting at least one hydraulic fluid-containing cavity in each of a second set of the hydraulic actuators to a position control function.

48. The method of Claim 47, wherein a gripper comprises first and second hydraulic actuators and wherein at least a first cavity in the first hydraulic actuator is set to the pressure control function and at least a second cavity in the second hydraulic actuator is set to the position control function.

49. The method of Claim 47, wherein a first hydraulic actuator comprises first and second cavities for receiving hydraulic fluid and wherein the first cavity is set to the pressure control function and the second cavity is set to the position control function.

50. The method of Claim 47, wherein the first and second sets of hydraulic actuators are at least partially overlapping.

51. The method of Claim 47, further comprising:

setting at least one cavity in at least one of the hydraulic actuators to a differential position control function.

52. The method of Claim 47, further comprising:

setting at least one cavity in at least one of the hydraulic actuators to a cooperating position/pressure control function.

53. A method for realizing a desired pitch and roll in an excavator, comprising:

providing an excavator, the excavator comprising a plurality of grippers operable to exert pressure on opposing surfaces of an excavation to maintain a desired position and orientation of the excavator;

receiving an attitude command containing desired settings for pitch and roll; and

converting the attitude command into separate actuator control commands for each of the plurality of grippers.

54. The method of Claim 53, further comprising:

forwarding the actuator control commands to each of the plurality of grippers; and

thereafter receiving position feedback signals from each of the plurality of grippers.

55. The method of Claim 54, further comprising:

converting the position feedback signals into pitch and roll values;

comparing the pitch and roll values with the pitch and roll values in the attitude command; and

determining an error vector, the error vector comprises an adjustment for roll and an adjustment for pitch.

56. The method of Claim 55, further comprising:

converting the adjustment for roll and adjustment for pitch into actuator control commands.

57. An automated method for excavating *in situ* material, comprising:

providing an excavator, the excavator comprising a body , a rotating boom, and a cutter head, wherein the excavator comprises a memory storing a profile of an excavation face;

rotating the boom while the cutter head is in contact with the excavation face to remove material from the face;

determining a revised profile of the excavation face after the rotating step; and

updating the profile of the excavation face stored in the memory.

58. The method of Claim 57, wherein the profile is a plan view of the excavation face.

59. The method of Claim 57, wherein the profile is a cross-sectional side view of the excavation face at a plurality of selected points along the face.

60. An excavator, comprising:

a boom;

a cutter head, mounted on the boom, for excavating *in situ* material, wherein the boom includes at least one thrust actuator operable to extend and retract the cutter head;

a body, wherein the boom is rotatably mounted on the body;

a plurality of grippers operable to apply pressure against opposing surfaces of an excavation to hold the body in a selected position and orientation; and

an optimization module operable to monitor a selected excavation parameter and effect a change in the operation of the cutter head when the monitored selected excavation parameter one of exceeds or falls below a predetermined threshold.

61. The excavator of Claim 60, wherein the monitored excavation parameter is a grade of a material removed during cutter head operation and wherein, when the grade falls below a selected value, the position of the cutter head relative to the excavation face is changed.

62. The excavator of Claim 60, wherein the monitored excavation parameter is a quantity of material removed during cutter head operation and wherein, when the amount of material falls below a selected amount, a torque of the cutter head can be increased.

63. The excavator of Claim 60, wherein the monitored excavation parameter is a quantity of material removed during cutter head operation and wherein, when the amount of material exceeds a selected amount, a torque of the cutter head can be decreased.

64. The excavator of Claim 60, wherein the monitored excavation parameter is a drag force exerted on the cutter head as a function of time during rotation of the boom and wherein, when the drag force falls below a selected amount, an angle of swing of the boom is altered.

65. A method for excavating *in situ* material, comprising:

providing an excavator, the excavator having a rotatable boom and a cutter head mounted on the boom for excavating the *in situ* material by rotating the boom back and forth across an excavation face while the cutter head is in contact with the excavation face for at least a portion of each boom rotation; and

automatically reversing a direction of rotation of the boom when a swing cycle optimization module detects that the cutter head is no longer in contact with the excavation face.

66. The method of Claim 65, wherein the swing cycle optimization module automatically reverses the direction of boom rotation when at least one of a hydraulic pressure measured in at least one thrust actuator and the swing torque drops below a predetermined threshold.

67. A method for controlling thrust pressure, comprising:

providing an excavator, the excavator comprising at least one thrust actuator for forcibly engaging a cutter head with an excavation face, the cutter head being mounted on a boom and comprising one or more excavating devices and the at least one thrust actuator operatively engaging at least one variable orifice valve for supplying hydraulic fluid to the at least one thrust actuator;

monitoring a parameter that is at least one of (a) a thrust force applied on the cutter head by the at least one thrust actuator, (b) a force on a cutter; (c) a speed at which the boom is rotating, and (d) a swing torque by the boom;

when the parameter exceeds a selected threshold, opening the at least one variable orifice valve a selected amount to relieve the pressure in the at least one thrust actuator.

68. The method of Claim 67, wherein the monitored parameter is (a).

69. The method of Claim 67, wherein the monitored parameter is (b).

70. The method of Claim 67, wherein the monitored parameter is (c).

71. The method of Claim 67, wherein the monitored parameter is (d).

72. The method of Claim 67, wherein the selected amount is a function of one or more of the amount by which the cutter force exceeds a selected value, the speed at which the cutter force is increasing, and an amount of time that the selected value has been exceeded.

73. The method of Claim 67, wherein the selected amount is a function of one or more of the amount by which the difference between a commanded boom rotational speed and an actual boom rotational speed exceeds a selected value, the speed at which the speed difference is increasing, and an amount of time that the selected value has been exceeded.

74. The method of Claim 67, wherein the selected amount is a function of one or more of the amount by which the swing torque exceeds a selected value, the speed at which the swing torque is increasing, and an amount of time that the selected value has been exceeded.